TABLE I. *Neutron-nucleus cross section for slow and fast neutrons.*

		Neutron-nucleus cross section $\times 10^{24}$ cm^{-2}	
Material	Atomic weight	Slow neutrons	Fast neutrons
H	1	13.3	1.68
D	2	3.4	1.71
Li	6.94	49	1.84
Be	9.02	3.8	1.65
B	10.82	600	1.60
C	12.0	2.8	1.65
O	16.0	3 est.	
F	19	<4	
Na	23	4.5	
Mg	24.3	2.5	
Al	26.97	1.9	2.4
Si	28.06	2.0	
P	31.03	7.2	
Cl	35.46	38	
K	36.1	34 est.	
Ca	40.07	<10	
Ti	48.1	<8	
Cr	52.01	7.4	
Mn	54.93	8.0	
Fe	55.84	7.8	3.0
Co	58.94	26	
Cu	63.57	5.9	3.2
Zn	65.38	3.6	3.3
Se	79.2	12	
Zr	91	17	
Sn	118.7	3.6	4.3
Sb	121.8	8	
I	126.93	10.1	4.6
Ba	137.37	100	
W	184.0	19	5.3
Hg	200.6	430	5.8
Pb	207.2	6.1	5.7
U	238.17	100	

express the cross-section value for those slow neutrons which disintegrate Li and are strongly absorbed by Cd. The results for high energy Rn-Be neutrons not slowed down by paraffin, from previous measurements,[2] are included in the last column. The corrections for the somewhat different geometrical conditions in the two sets of data have not yet been completely made, but measurements of the cross sections for high energy Rn-Be neutrons, using spheres of lead and copper instead of paraffin in the arrangement of Fig. 1, indicate that the high energy cross sections should be multipled by about 0.85 to make them correct relative to the slow neutron measurements. The nature of the measurements at this stage is such that the results, especially for the large absorptions, do not have much precision. We estimate that most of the smaller cross-section values are accurate to well within 10 percent, but the larger values within ± 25 percent.

While the variation of the cross section of nuclei in general with slow neutrons compared to fast neutrons will certainly be of theoretical significance, some elements having practically the same value (considering the geometric factors), others increased only slightly, and some increased enormously, probably one of the most interesting points in the table is the large increase in cross section of the proton compared to the deuteron.

The relative effects of H_2O and D_2O in enhancing the efficiency of neutrons in the production of artificial radioactivity in silver was tested by activating a strip of silver suspended above a Rn-Be source at the bottom of a test-tube, first in air, then immersed in 200 cc of H_2O, then in the same volume of D_2O (99.8 percent). The 2-min. period radioactivities obtained in air, H_2O and D_2O were respectively as 1, 2.0 and 6.5. Subtracting the direct effect in air, the enhancing effect of H_2O was 5.5 times that of D_2O.

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[1] Am. Phys. Soc. Bull., Feb. (1935).
[2] John R. Dunning, Phys. Rev. **45**, 586 (1934).

The East-West and Longitude Effects

In measuring the difference between the numbers of charged particles effecting a line of Geiger-Müller counters when it is tilted toward the west and then toward the east, the common practice is to rotate the line of counters about an axis normal to the equipotential gravitational surface at the location in which the experiment is being conducted. Now it has been shown in sea-level surveys by Clay[1] and by Millikan and Neher[2] that the variations in the surface magnetic field for the same geomagnetic latitude extend to sufficient heights to influence the charged particles coming in at the equator, giving rise to the "longitude effect." Our present surveys show this effect to be from 4 to 5 percent of the total intensity of the cosmic radiation at sea level. A glance at a map showing lines of equal horizontal intensity of the earth's magnetic field will show that these variations are quite large and extend over wide areas. As an example, on the coast of Peru where Johnson[3] and Korff[4] have studied the east-west effect, the horizontal intensity is 0.30 gauss while 8000 kilometers to the west it has increased to 0.35 gauss and has diminished to something like 0.28 gauss in the first 5000 kilometers to the east. These distances are of the same order as the radius of curvature of a charged particle which is just able to reach the earth's surface at this latitude and consequently will be influenced by these variations. A rough calculation shows that the surfaces of equal magnetic intensity in this region are tilted upward toward the west at an angle of several degrees. In order for the results of the east-west measurements to be interpretable, the axis of rotation of the counters must be more nearly normal to these surfaces of equal magnetic intensity. This means that the axis of rotation of the counters must be inclined *east* of the vertical.

Now it can easily be shown that the full east-west effect found by Johnson can be eliminated if the axis of rotation of the counters is tilted about two degrees west of the normal to the equipotential gravitational surfaces, and if the axis of the counters is set more nearly normal to the surfaces of equal magnetic intensity, this angle becomes two to four degrees in South America. The east-west effect then increases from six to eight percent to something like six to sixteen percent at sea level, the exact amount depending on the ratio of electrons to photons and the effect of the earth's atmosphere in absorbing each.

In the African region the effect should be in just the opposite direction, i.e., to perform an east-west effect experiment in this region one should tilt the axis of rotation of the counters toward the *west*. One should then expect to find an east-west effect near the equator in both South America and Africa even though there were equal numbers of positrons and negatrons with the same energy distribution coming into our atmosphere. Under these conditions in South America there would be a preponderance toward the east and in Africa a greater number toward the west.

The influence of the atmosphere, which lies between two equigravitational surfaces, would be to make the effective angle of inclination to the vertical of the axis of a line of counters less than it would be otherwise.

In support of this suggestion the experiments of Johnson in South America and Rossi[5] in Africa may be cited. At 8000 feet Rossi gets a maximum west excess of 16 percent at a point 11° *north* of the magnetic equator, while Johnson, *on* the magnetic equator would get about 12 percent.

The point to be noted is the fact that setting the axis of rotation of a line of counters parallel to the line of a plumb-bob loses its meaning as far as the east-west effect is concerned in certain locations and interpretations must be made by taking proper account of the dissymmetry of the earth's magnetic field.

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February 18, 1935.

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[2] R. A. Millikan and H. V. Neher, Phys. Rev. **47**, 205 (1935).
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[5] B. Rossi, Phys. Rev. **45**, 212 (1934)

On the Low Temperature Diffusion of Solid Aluminum into Iron

The writer has recently noted the comparatively rapid diffusion of solid aluminum into steel at low temperature.

A built-up gasket of aluminum foil was used in a bolted tongue-and-groove type joint between the body and cover of a steel autoclave, being held under very considerable mechanical pressure by the bolts. After carrying out a digestion for six hours at 290°C, it was found that the gasket had welded to the groove at points near the bolts, where the pressure was greatest; and in machining out the aluminum, it was found to have penetrated into the steel to a depth of nearly a millimeter below the original surface of the groove at the points of welding.

The groove had been freshly cut and probably retained traces of machine oil. The foil had been moistened with turpentine, which strongly wets aluminum, before use. Although no direct measure of the pressure between the aluminum and steel could be made, the apparatus had been tight in previous work against water above its critical temperature, which would require a gasket pressure in the neighborhood of one thousand kg per sq cm.

As no notice was found on such low temperature diffusion of aluminum into steel or iron, the writer improvised a small nichrome furnace for heating under controlled atmosphere and has been studying the diffusion of aluminum into iron over the temperature range 300° to 900°. This study is still far from complete, but has progressed far enough to warrant the publication of a few general results, which are outlined below:

(1) Aluminum will diffuse into steel and into cast iron at 300° provided both surfaces are clean and sufficient pressure exists at the interface to assure full surface-to-surface contact.

(2) The rate of diffusion is a direct function of the pressure, as yet undetermined.

(3) The pressure necessary to produce a given rate of penetration varies as an inverse function of the temperature. Penetration without substantial pressure has not been observed below the melting point of aluminum.

(4) If the surface of either metal is old or oxidized, diffusion does not occur at any pressure within reach.

(5) The rate of penetration under similar conditions varies as much as fifty percent between different kinds of iron or steel.

(6) At the temperature of melting aluminum, this metal diffuses upward through a bar of iron or steel whose lower end is immersed in aluminum at the rate of one to two cm per day, depending on the character of the ferrous metal; and the penetration continues until the whole bar is impregnated.

(7) The specific gravity of the steel or iron so treated is increased; the largest observed increase being about $2\frac{1}{2}$ percent. (Note that Al–Fe alloys prepared by fusion are of lower specific gravity than that of iron, though in general higher than the weighted mean of the specific gravities of the two metals.)

(8) The electrical, conductivity of iron or steel wire is noticeably increased by low temperature impregnation with aluminum.

(9) Machining and grinding characteristics of iron and steel are not materially changed by low temperature impregnation with aluminum.

(10) Above the temperature of melted aluminum, the slow diffusion of iron into the aluminum becomes noticeable in addition to the reverse process; becoming more rapid as the temperature is raised. The original outline of a bar of steel immersed in aluminum was completely lost in 20 hours at 750°, and the original structure of a steel bar $2\frac{1}{2}$ cm dia. by 10 cm long was lost throughout after 20 hours in aluminum at 900°. It had become hard, brittle and of lower specific gravity than the original steel.

The above notes make it appear that the low temperature penetration of iron by aluminum is mainly a capillary flow in the intercrystalline pores of the iron, with at the most only a superficial disturbance to the structure of the latter. This also seems probable on the basis of microscopic examination of etched specimens. If so, one would expect the treated iron to be both stronger and more impervious